25X1 [redacted] No. A-3 ~~7~~ 25X1
Pages 1 w/68 pp of attachments
Copy 1 of 2

[redacted]

CONFIDENTIAL

file #99711-3

April 10, 1967
Ref: 611/PLI-82

25X1 [redacted]
P. O. Box 6788
Fort Davis Station
Washington, D. C. 20020

25X1
Attention: [redacted]

Reference:

Subject: Exposure Control Report

Gentlemen:

Four (4) copies of a report entitled "Exposure Control for the Contact Duplicating and Reseau Printer" are enclosed. This report was given to [redacted] on a recent visit here. 25X1

Yours truly,

INFORMATION SYSTEMS
MARKETING AND PLANNING DEPARTMENT

[redacted] 25X1

Contract Administrator

WK:ks

Encs.

"This material contains information affecting the national defense of the United States within the meaning of the espionage laws, Title 18, U. S. C., sections 793 and 794, the transmission or revelation of which in any manner to an unauthorized person is prohibited by law."

CONFIDENTIAL

NGA Review Complete

25X1 [redacted]

EXPOSURE CONTROL

CONTACT DUPLICATING AND RESEAU PRINTER

Philosophy of Automatic Exposure Control

The characteristics of the automatic exposure control system for the Contact Duplicating and Reseau Printer were evolved after detailed discussions with the Government Monitors, with consultants, after evaluation of many alternate approaches and specific experimental testing of this configuration.

In accordance with Paragraph 3.8* of the contract specification, information transfer must be accomplished with minimum loss of resolution. From subsequent discussions, it developed that compensation was desirable for gross variations in average density along the frame length, as frequently encountered in panoramic photography. Although specific information regarding the spatial and densitometric distributions within the input films was not available due to security restrictions, assumptions were made based on an exhaustive literature search of typical aerial photography.

It is well known that all photographic materials have an optimum exposure at which the maximum resolution potential of the film is attained. This is somewhat dependent on input contrast and subsequent processing but in general affords a basis for setting exposure to attain maximum resolution. It was established in early discussions that a system which provided local control of exposure was to be incorporated in this printer.

*3.8 Exposure Control - The exposure light shall provide for the transfer of images from the negative to the output film with an absolute minimum of distortion and resolution loss. The light source and exposure control system shall be designed for compatibility with Kodak Fine Grain Aerial Duplicating Film, Type 8430 (formerly SO-278), through a density range of 0.2 to 3.2.

A scanning CRT type of exposure system, such as used in the Log-E printer, was not applicable to this printer because of the printing speed requirement and the relatively low output of state-of-the-art CRT devices. A calculation supporting this is attached in Appendix B.

There were a number of obvious advantages to a fixed matrix of lamps, each controlled by its own photosensor. It afforded local control, and therefore an opportunity to optimize local exposure for maximum transfer but accommodated this without any moving parts. A matrix of 96 lamps was selected for 9" x 30" format to give control along the length as well as across the width. Since the matrix is fixed, the degree of control reduces with frame size.

In this design, a photocell above the printing platen receives the light transmitted by the input negative and the unprocessed rawstock and integrates it to determine exposure. Specific exposure conditions are controlled by the operator in terms of a rawstock selector switch and an override which allows for four multiples of normal exposure in the event average density is not the best criterion. The nominal area controlled by a lamp and its photocell is approximately 2" x 2", although the specific effect of each is considerably broader to minimize patterning of the output prints.

The obvious extremes of exposure control are uniform exposure over the entire platen, which is afforded in this printer in the manual printing mode, and local control such that the spot size which is variably controlled is less than or equal to the minimum grain size of the detail in the negative. Here, with a perfectly compensating system, the output would be uniform grey.

Obviously, a realistic solution represents a compromise. Assumptions must be made about the spatial and densitometric distributions of density and for any combination of conditions for which the system is optimized. Others can be demonstrated where density discontinuities are exaggerated.

The variables are spot size, degree of feedback, direction of scan (in a scanning mode) and average output density programmed into the machine. It can be demonstrated that an edge effect is created in a dodging (locally controlled) printer at a discontinuity of density in the input negative. The magnitude of the effect is controlled by the variable factors listed above. The area affected can be reduced by reducing spot size, the magnitude of the densitometric effect can be controlled by limiting the amount of feedback. Once these assumptions are made, however, the situation is inflexible. The only way to completely eliminate it (except for a random scanning printer which is impractical for the printing speeds required) is to provide uniform exposure.

Sensitometry

Figure 1 is a representation of the tone reproduction characteristics of typical negative and duplicating films. As an example, if the negative input to be duplicated is a panoramic scene, a microdensitometer profile would be similar to Figure 2A where the dotted line is the midpoint of the straight line portion of the duplicating material. Since incremental areas are being sensed separately and exposed the average density over the frame length may appear as shown in Figure 2D. The integrated exposure control readout would be expected to place the exposure for the incremental area about the optimum point of the straight line portion of the duplicating material and in the region of maximum resolution as shown in Figure 2B and Figure 2C. In so doing, the resulting positive will have a profile similar to Figure 2E.

As in any exposure control system, it is desired to print every density of the negative within the straight line portion of the duplicating film while preserving the ΔD's (contrast) within the negative. To achieve these conditions in an incremental area exposure control system with minimum error requires a detailed knowledge of the input and output conditions as well as trade offs. Therefore, compromises must be made in order to achieve acceptable results in a reasonable duplicating time. The aspect of area size related to contrast distortion is discussed in the section dealing with an Analysis of Area Exposure Control System.

Figure 3 contains the spectral sensitivity of the two duplicating films now being used.

Appendix A contains a derivation for the exposure time based upon known conditions.

Approved For Release 2005/06/23 : CIA-RDP78B04770A001600020002-2

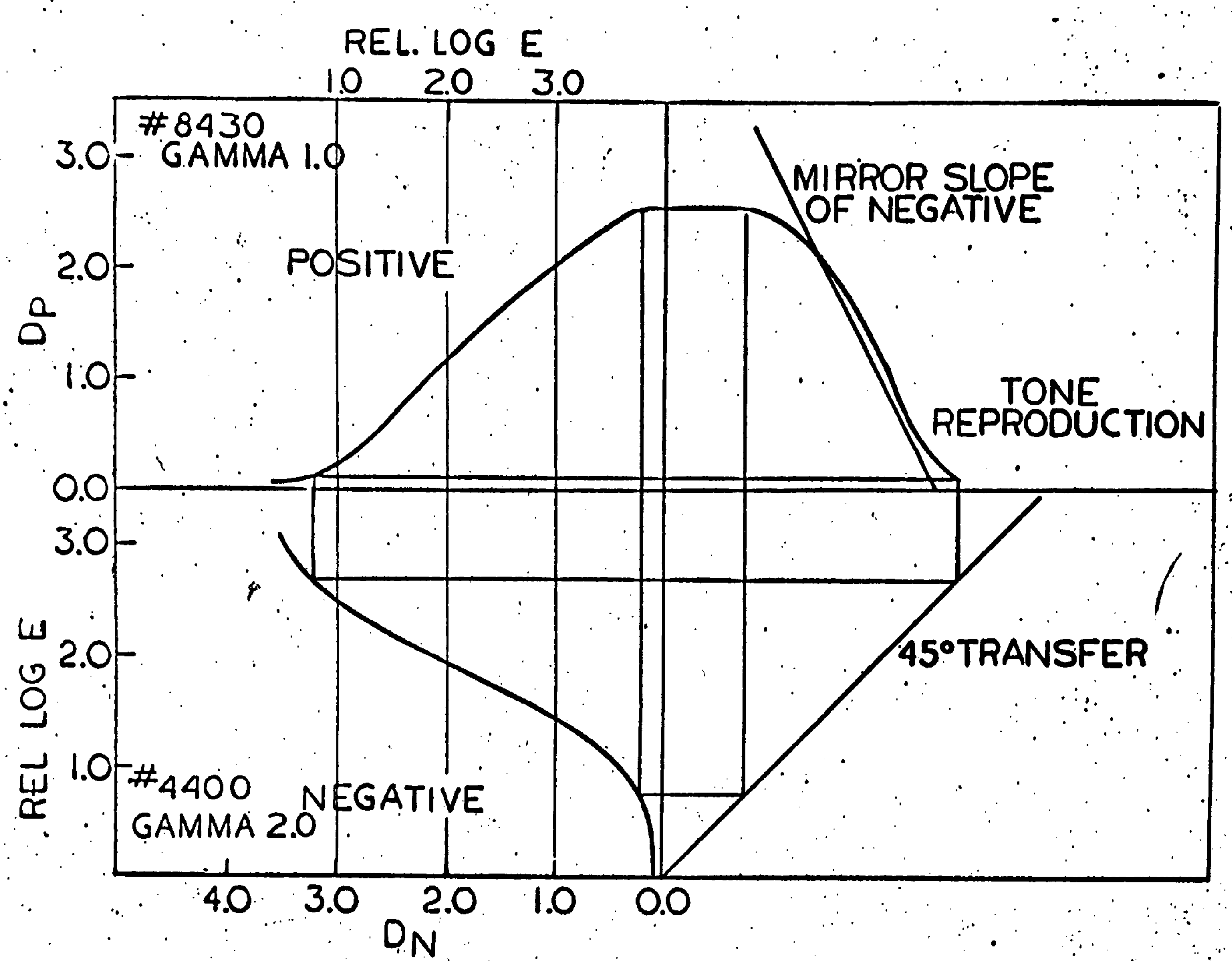
REL. LOG E
1.0
2.0
3.0
#8430
GAMMA 1.0
3.0
2.0
1.0
0.0
D_P
POSITIVE
MIRROR SLOPE OF NEGATIVE
TONE REPRODUCTION
3.0
2.0
1.0
REL LOG E
45°TRANSFER
#4400
GAMMA 2.0
NEGATIVE
4.0
3.0
2.0
1.0
0.0
D_N

FIGURE 1

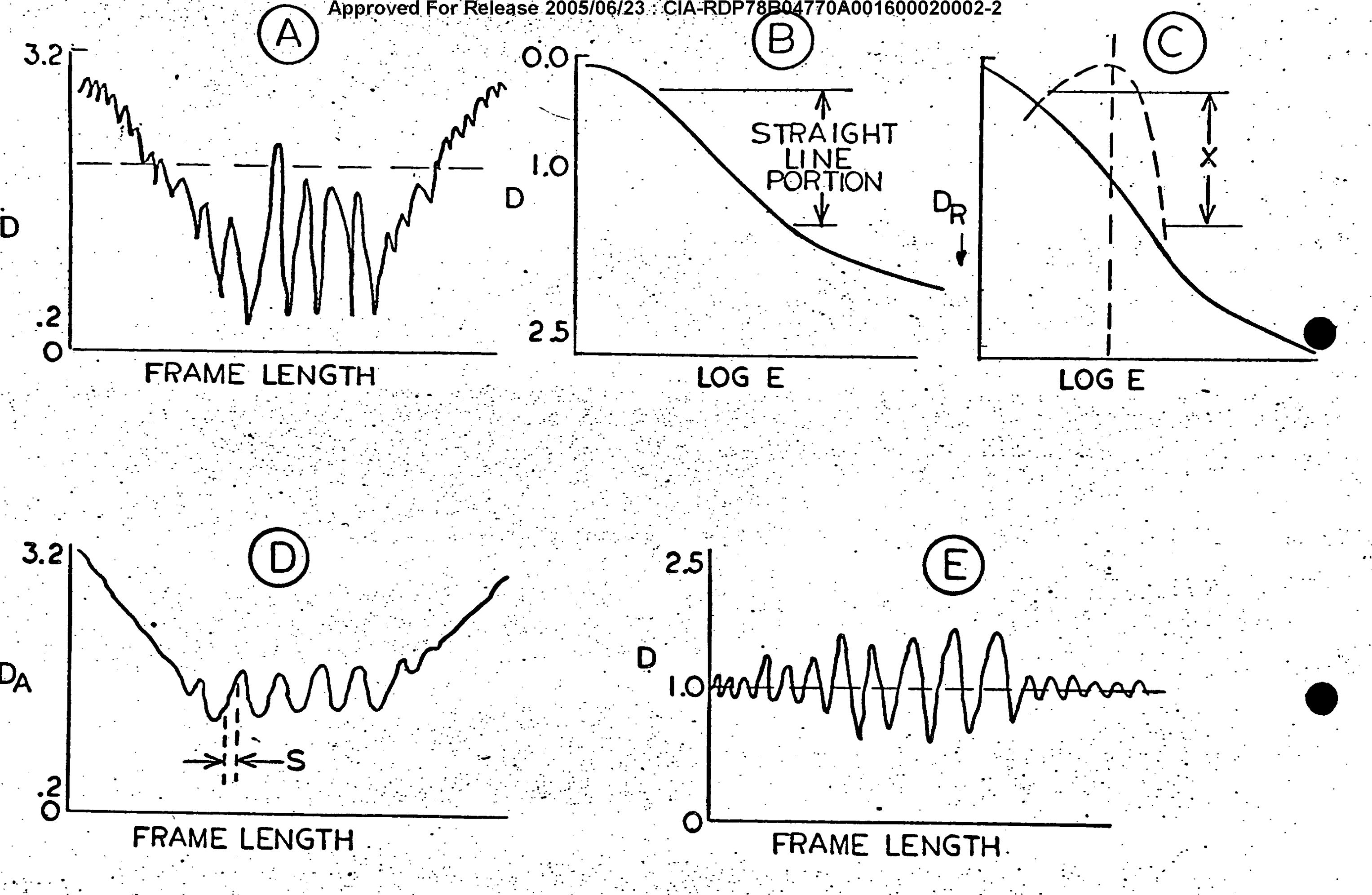

FIGURE 2

Panoramic Frame Negative and Positive Density Profile

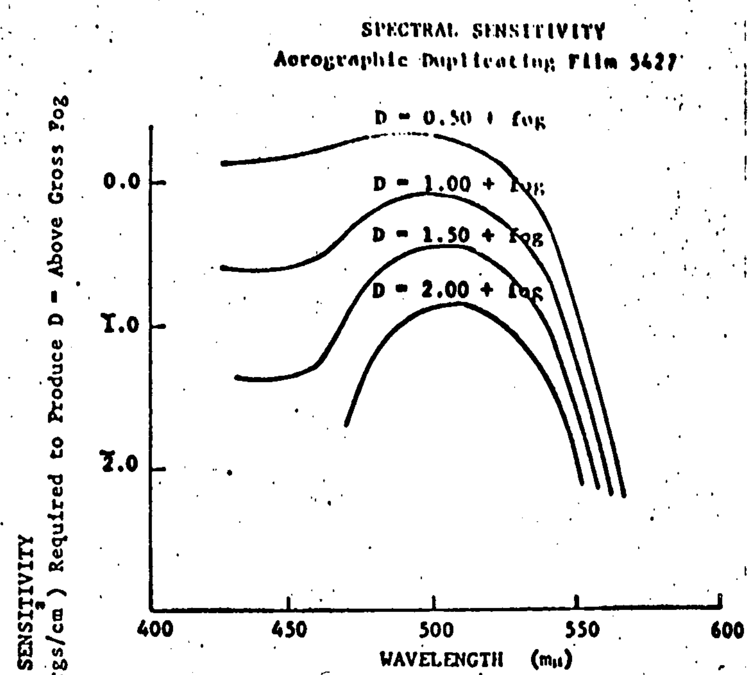

Figure IV.

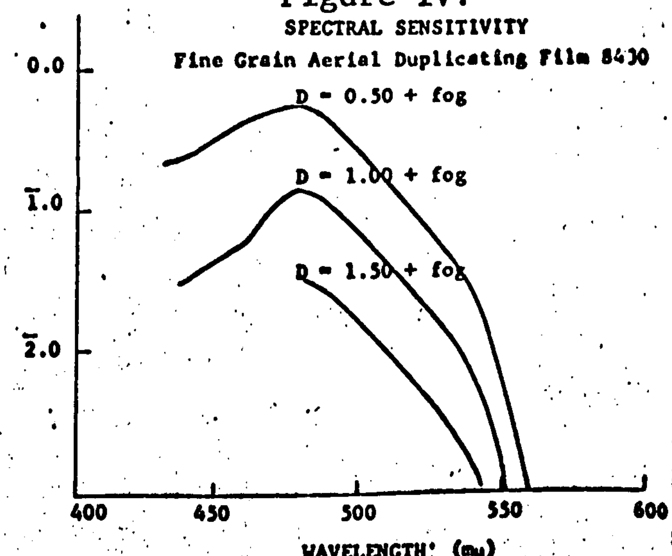

Figure 3

Analysis of Area Exposure Control

Consider the case of a uniform light intensity at the printing gate as shown in Figure ˉ caused by lamps L_1, L_2, L_3, etc. having a triangular intensity pattern as shown in Figure II. This provides an area exposure system approximating the actual machine configuration with lamp cross-talk.

Inserting a negative having a step difference in densities, we will assume the greater density area has a transmittance of 0.2 and the lighter density a transmittance of 0.8 with the discontinuity directly above a lamp, Figure III. The sensors are directly above each lamp and they will see an average intensity over the area they control. Since the sensor directly above the discontinuity sees half dark and half light areas, it will register the average value, Figure IV. For a constant exposure (E= Intensity x Time) the time each lamp is on can be easily computed to be as shown in Figure V.

Knowing the time each lamp is on (Figure V) and the intensity distribution, the exposure (E) input to the negative may be determined as in Figure VI. Since this energy must pass through the negative to reach the duplicating film, we must multiply this exposure by the transmittance of the negative at each point of the negative. This results in raw stock exposure as shown in Figure VII. It is interesting to note from Figure VII the contrast may change a little but its effect in an area exposure control system can be spread over as much as twice the fundamental area of control and in no case less than one area of control. This effect applies to all such systems irrespective of the size of area selected.

Where the density discontinuity may exist between lamps, the effect is shown in Figures VIII through XIV.

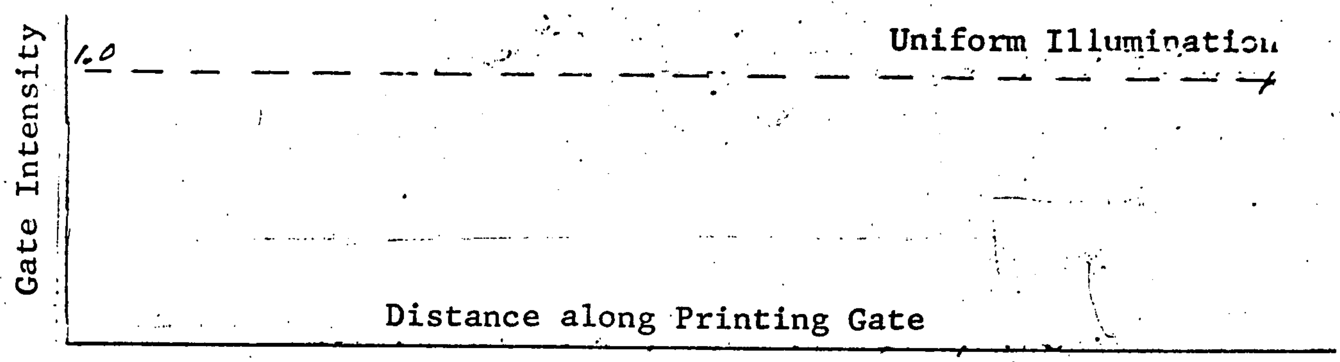

Fig. I

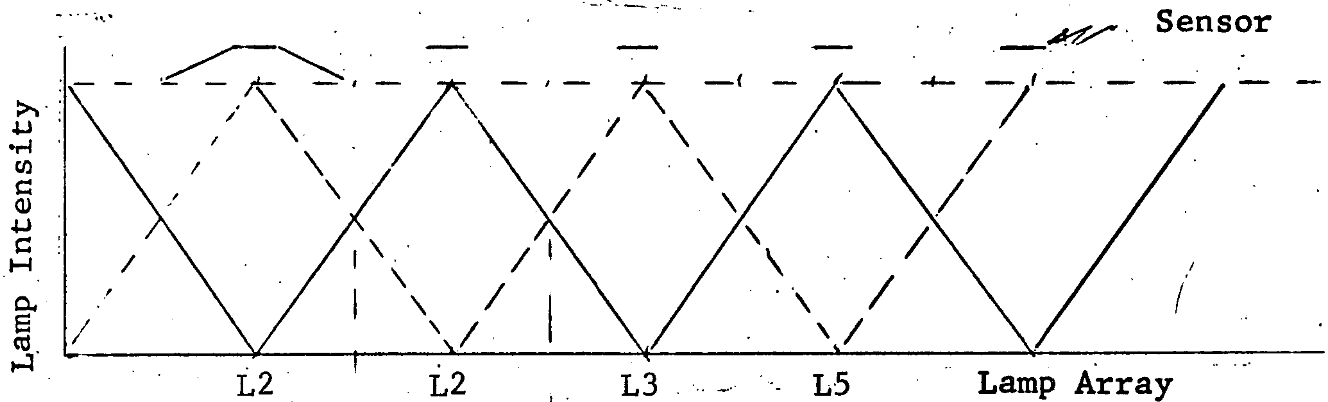

Fig. II

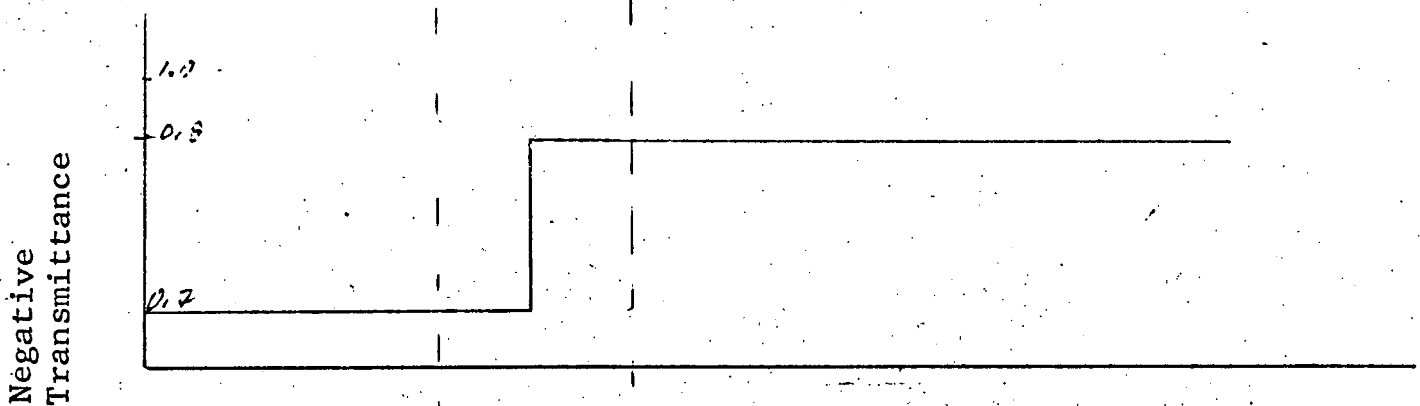

Fig. III

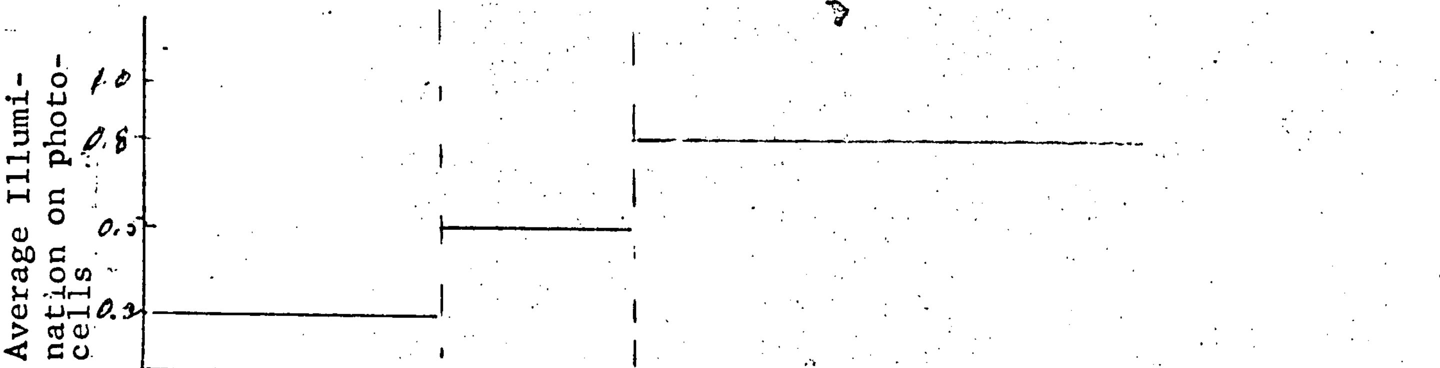

Fig. IV

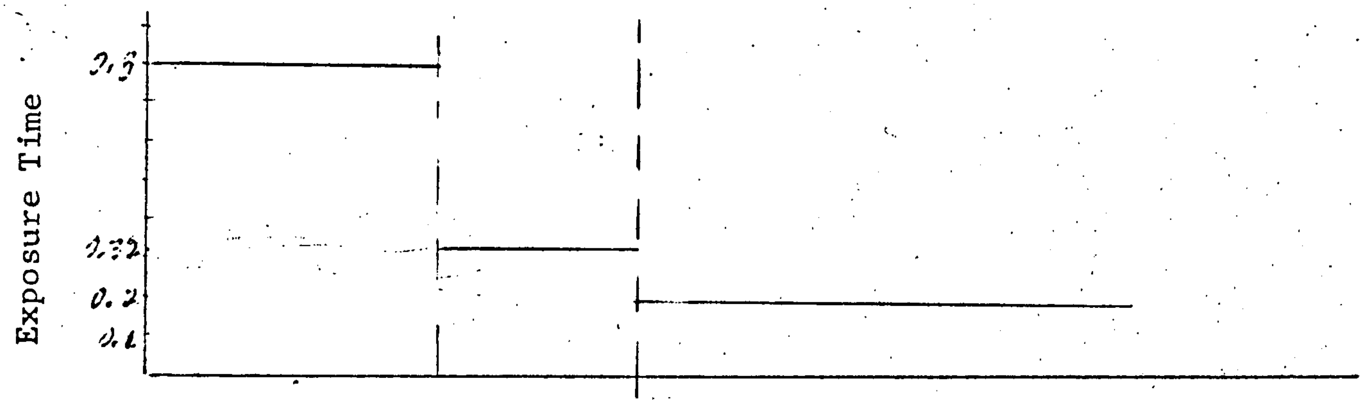

FIG V.

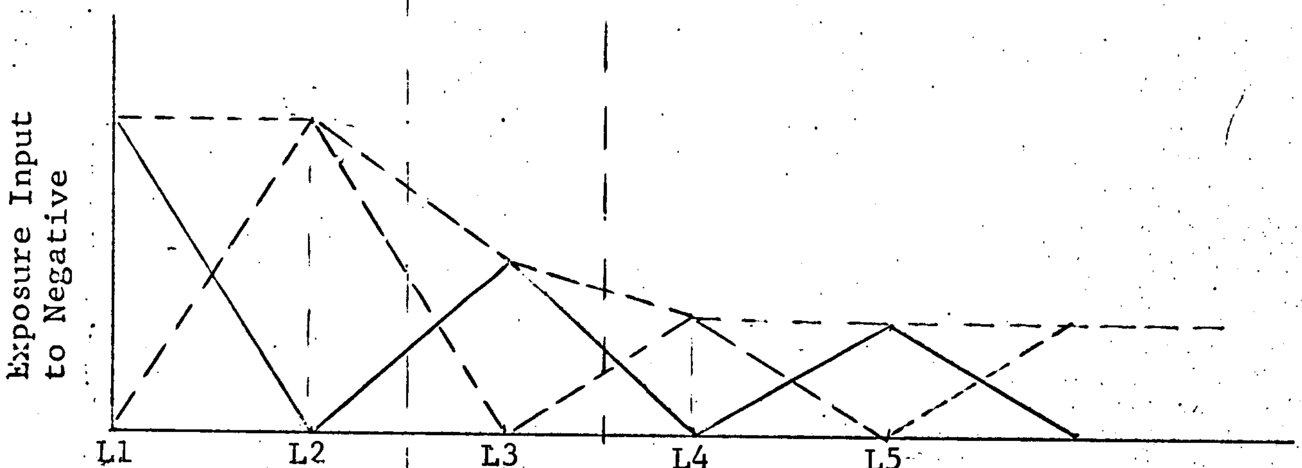

FIG VI.

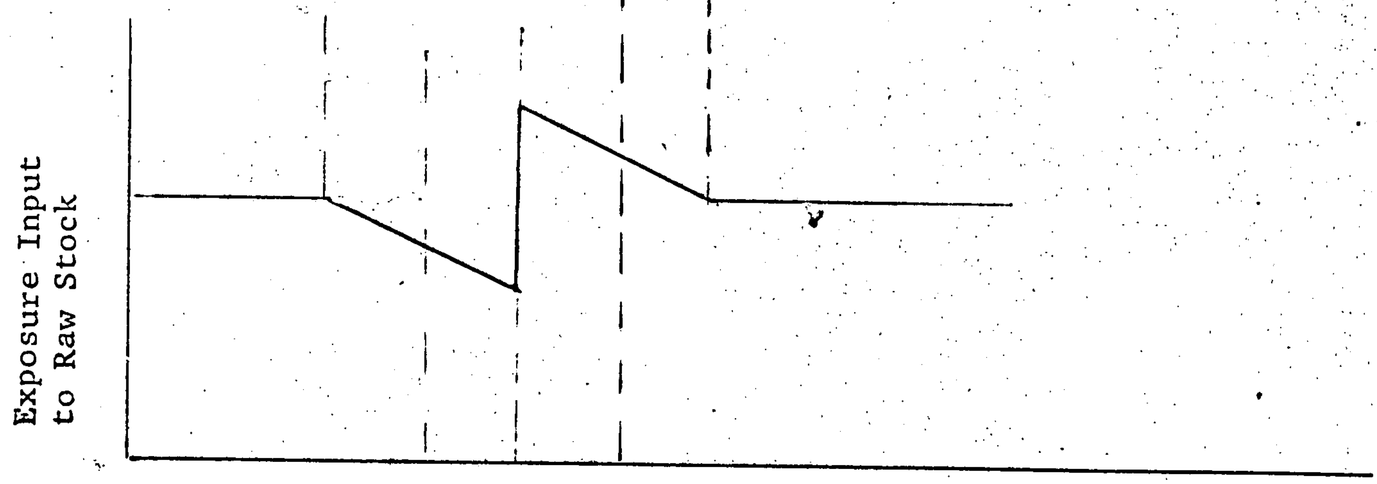

FIG VII.

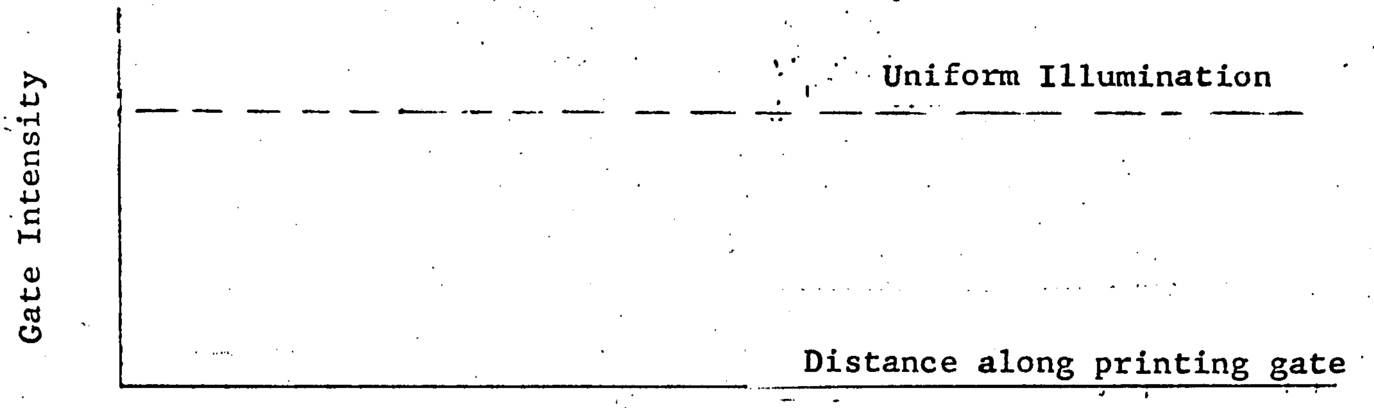

FIG VIII.

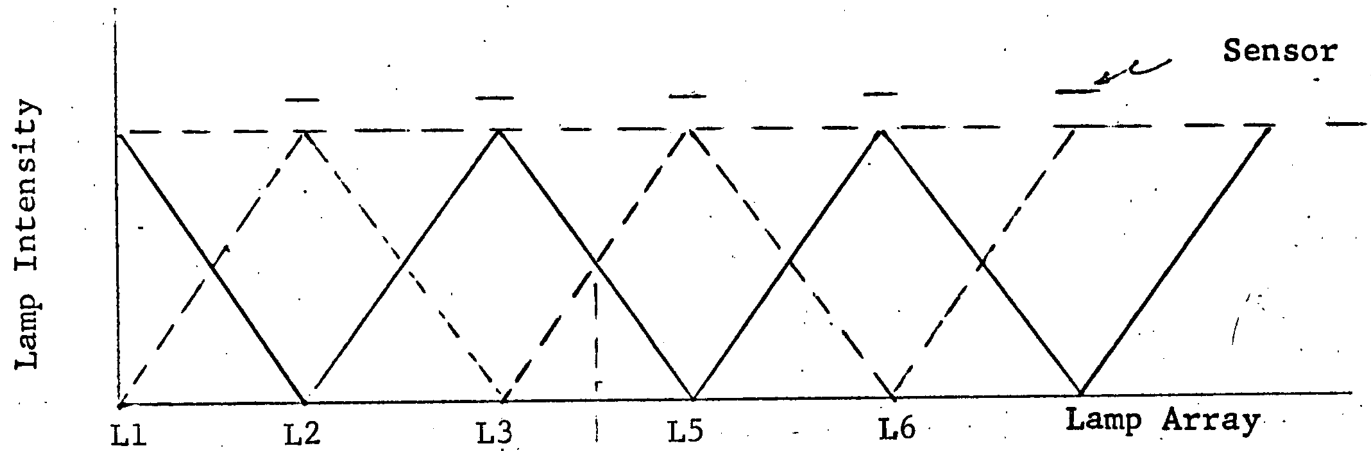

FIG. IX.

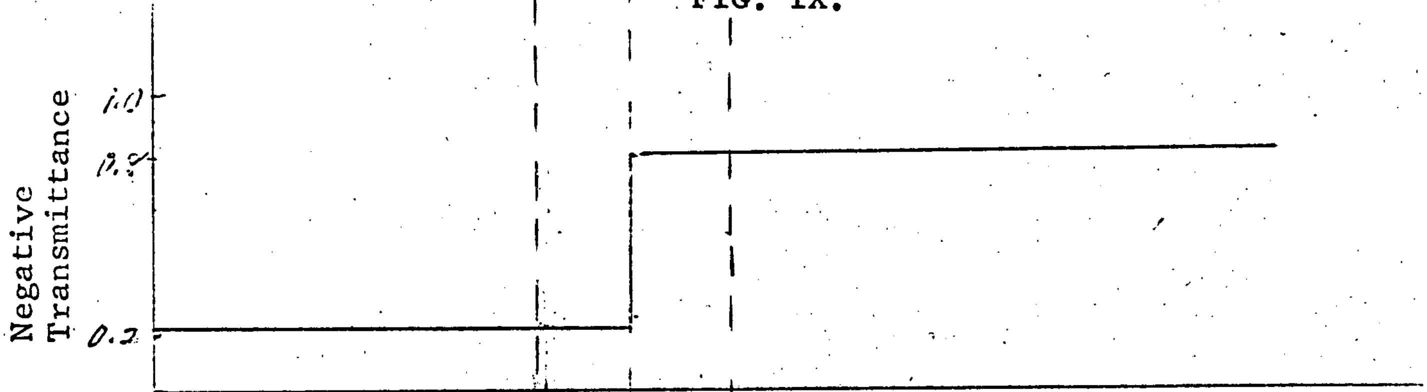

FIG X.

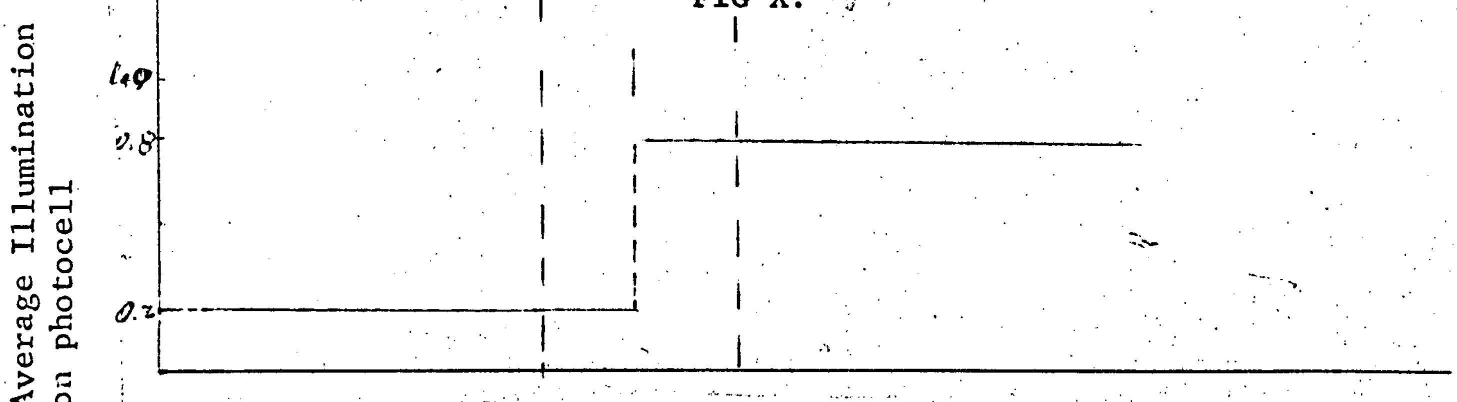

FIG. XI.

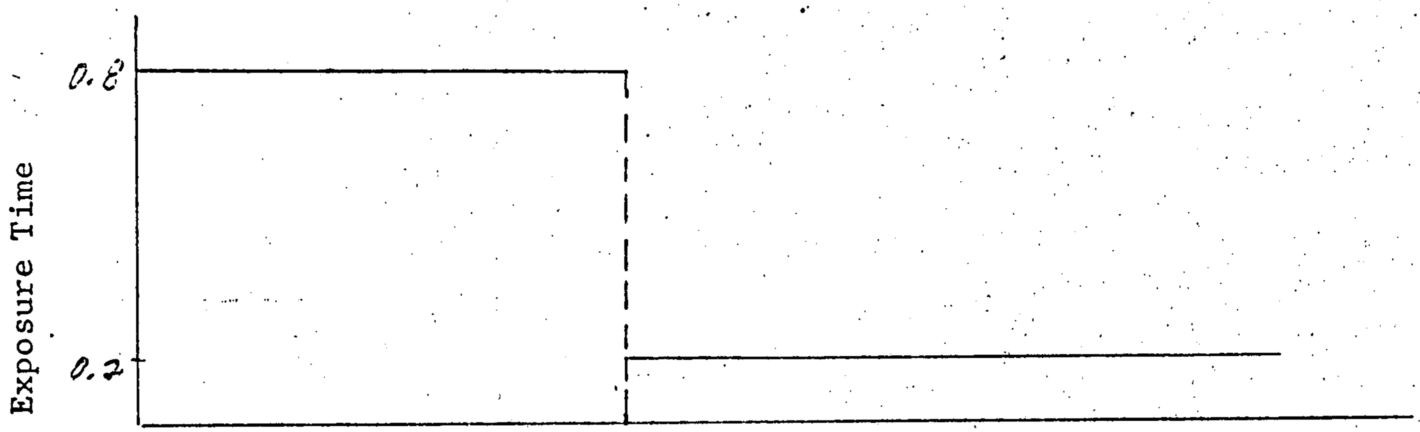

FIG. XII

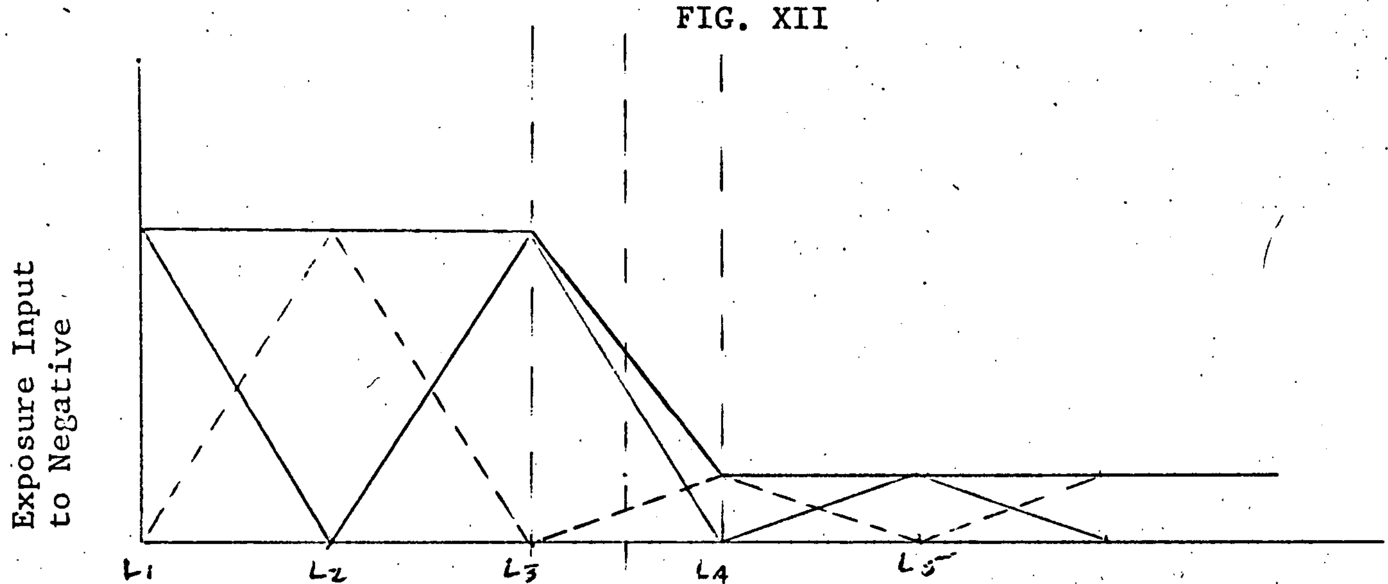

FIG. XIII

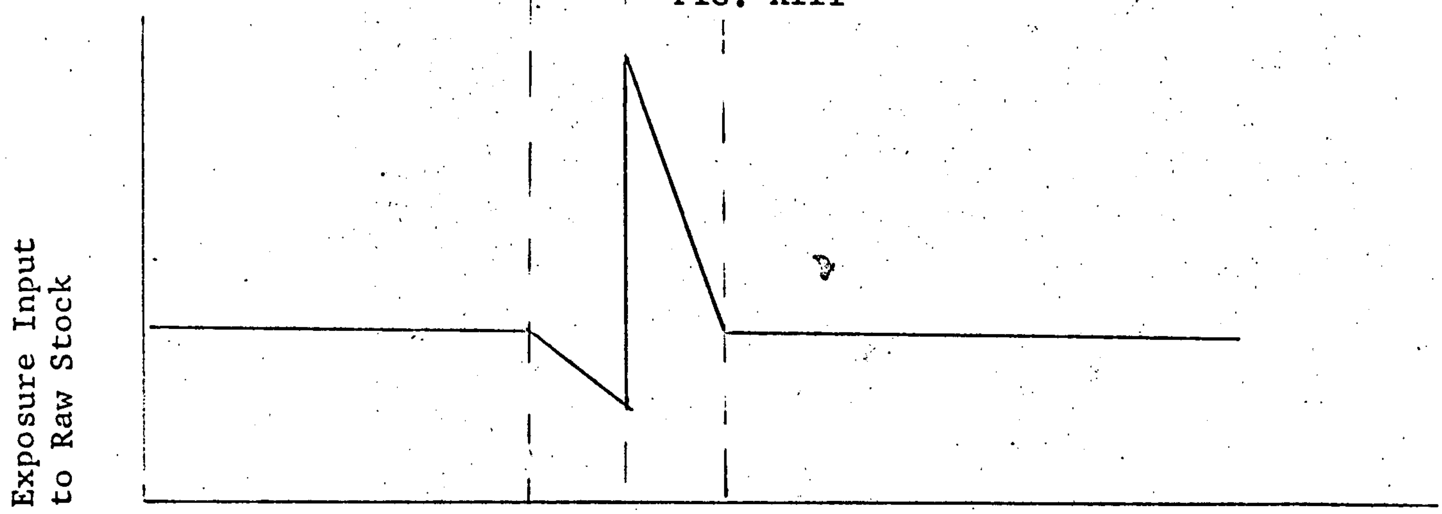

FIG. XIV

APPENDIX A

Mathematical Derivation - Automatic Exposure Control

Each post-negative illumination sensor "looks" at its corresponding source lamp through the air-bag wall with transmission T_B, the raw stock with transmission T_F, the negative with transmission T_N, the gate with transmission T_G and the post-source optics with transmission T_O. Thus the sensor receives the illumination of the source, H_S, as the quantity $H = T_B \bullet T_F$ $T_N \bullet T_O \bullet H_S$. The sensor is a photo-current generator with output current, I_O of: $I_O = K_1 H$. Therefore, the sensor will generate a current equal to: $I_O = K_1 \; H_S \; T_B \; T_F \; T_O \; T_N$. The sensor output current will be amplified by a factor of $A = \dfrac{K_2}{T_B \; T_F \; T_O}$ (T_B T_F and T_O are system constants), thus producing a current of $I_C = K_1 \; K_2 \; H_S \; T_N$

This current, I_C, is used to charge a capacitor C_I from V_1, the exposure start reference, to V_2, the exposure stop limit. Thus:

$$V_2 - V_1 = \frac{1}{C_I}\int_0^{T_E} K_1 \; K_2 \; H_S \; T_N \; dt$$

But K_1 K_2 H_S and T_N remain constant during the exposing time of the particular negative area. Therefore,

$$H_S \; T_N \; T_E = \frac{(V_2 - V_1) \; C_I}{K_1 \; K_2}$$

and since V_2 V_1, C_I, K_1 and K_2 are all constants, a particular equation can be defined as the exposure constant, K_E.

Thus:

$$\frac{(V_2 - V_1) \; C_I}{K_1 K_2} = K_E$$

Therefore:

$$H_S\ T_N\ T_E = K_E$$

Thus:

$$T_E = \frac{K_E}{T_N\ H_S}$$

and since the density of the negative D_N is:

$$D_N = \text{Log}\left(\frac{1}{T_N}\right)$$

Then: $\text{Log}\ (T_E) = \text{Log}\ (K_E) + D_N - \text{Log}\ (H_S)$

Where: T_E is the exposure time.

APPENDIX B

CRT BEAM ENERGY CALCULATIONS

Based on Articles and data from CBS Laboratories[1] and Eastman Kodak,[2] the CRT beam energy required to expose EK8430 duplicating film under two conditions has been calculated.

Condition 1

EK8430 film exposed for developable density of 0.3. Exposure of film made through a negative density of 3.0. Size of film and negative: 9 x 30 inches.

Condition 2

EK8430 film exposed for developable density of 1.0. Exposure of film made through a negative density of 1.0. Size of film and negative: 9 x 30 inches.

Condition 3

EK8430 film exposed for developable density of 1.0. Exposure of film made through a negative density of 2.0. Size of film and negative: 9 x 30 inches.

For these calculations, the best phosphor/film fit was selected (P11)* and most productive parameters assumed.

The equations used in the calculations were as follows:

$$\text{assume} \quad E_A = E_B$$

$$E_B = \frac{\eta\alpha\beta\gamma\theta P\tau}{A} \times 10^7 \ (\text{Ergs/cm}^2)$$

E_A = Required irradiance at negative to produce exposure (Ergs/cm^2)
E_B = Average irradiance at negative produced by CRT (Ergs/cm^2)
η = Phosphor conversion efficiency
α = Spectral transfer efficiency
β = CRT optical transmission efficiency
γ = Screen utilization factor
θ = Optical system transfer efficiency
P = CRT beam power (watts)
τ = The total exposure time (seconds)
A = The film area to be exposed (cm^2)
T = Optical transmission of negative

---

*P11, the most efficient phosphor for EK8430 film, has peak output at 460 mμ.

1. L. Beiser, Photo. Sci. Eng. 7, No. 3 (1963).
2. "Spectral Sensitivity Curve for Type 8430 Film," Eastman Kodak Co., Rochester, N.Y. (unpublished data).

$$\eta = 7 \times 10^{-2}$$
$$\alpha = 8.7 \times 10^{-1}$$
$$\beta = 9 \times 10^{-1}$$
$$\gamma = 5 \times 10^{-1}$$
$$\theta = 5 \times 10^{-1}$$

$$A = 1.74 \times 10^{3} \text{ cm}^{2} \text{ (9 x 30 inches)}$$

$$\therefore E_B = 7.87 \times 10^{1} \; P\tau \; \frac{\text{Ergs}}{\text{cm}^2}$$

For Condition 1:

Film requires: $E_A' = 10 \frac{\text{Ergs}}{\text{cm}^2}$ at 460 mμ*

where $E_A' = TE_A$

Negative density = 3.0 ($T = .001$)

$\therefore$ Negative incident energy $= 1 \times 10^{4} \frac{\text{Ergs}}{\text{cm}^2} = E_A$

$\therefore 1 \times 10^{4} = 7.87 \times 10^{1} \; P\tau$

$\therefore P\tau$ = 127 joules (watt-seconds)

For Condition 2:

Film requires: $E_A' = 67.7 \frac{\text{Ergs}}{\text{cm}^2}$

Negative density = 1.0

$\therefore$ Negative incident energy $= 6.77 \times 10^{2} \frac{\text{Ergs}}{\text{cm}^2} = E_A$

$\therefore 6.77 \times 10^{2} = 7.87 \times 10^{1} \; P\tau$

$\therefore P\tau$ = 8.6 joules (watt-seconds)

For Condition 3:

Film requires: $E_A' = 67.7 \frac{\text{Ergs}}{\text{cm}^2}$

Negative density = 2.0

$\therefore$ Negative incident energy $= 6.7 \times 10^{3} \frac{\text{Ergs}}{\text{cm}^2} = E_A$

$\therefore 6.7 \times 10^{3} = 7.87 \times 10^{1} \; P\tau$

$\therefore P\tau$ = 86.0 joules (watt-seconds)

---

*See footnote on preceding page (from Eastman Kodak data).

The highest state-of-the-art CRT beam power is 25 watts (excluding the projection type CRT). This beam power can be used only if (see ref. 1) the light spot velocity is kept above 10^6 cm/sec for the type of phosphor and phosphor application (fine-grain settled aluminized screen) assumed or (see ref. 2) by changing phosphor type and phosphor application to obtain a more rugged combination.

The high light spot velocity of 10^6 cm/sec or greater introduces virtually impossible deflection problems in a spot velocity modulation system and intensity modulation would introduce spot size modulation and uncertain overlap problems. The change of phosphor type and phosphor application (possibly to a polished, vapor reacted screen) to obtain a screen that could take the 25 watts at lower spot velocities could reduce the $\eta\gamma$ product from 3.5×10^{-2} to 1.75×10^{-3}, thus requiring the electron beam power to be increased to 500 watts to obtain the same light output.

Therefore, if 12.5 watts is assumed to be an <u>upper</u> limit on <u>usable</u> beam power in the system (and very high spot velocities are <u>still</u> required), then the required exposure times are as follows:

Condition 1:	127/12.5 = <u>10.2 seconds</u>
Condition 2:	8.6/12.5 = <u>0.66 seconds</u>
Condition 3:	86/12.5 = <u>6.6 seconds</u>

Only one of these conditions meets the printer requirements and this is questionable because the calculated exposure times are based on a combination of other optimistic parameters which do not take into account such factors as phosphor aging (which alone could multiply the exposure times by a factor of two).

25X1

[redacted]erm
April 4, 1967

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER TOPOGRAPHIC LABORATORIES
FORT BELVOIR, VIRGINIA 22060

FILE # 99711-3

IN REPLY REFER TO:
ETL- AMD

28 March 1968

Dear John:

25X1 Reference is made to the [redacted] for the Contact Duplicating and Reseau Printer.

The final acceptance test has been completed. In essence the printer conformed to the requirements of the contract except for accuracy. The specification required that the total alignment and printing error be within ± 5 microns. Although, the final acceptance test revealed an overall error on the order of 25-30 microns; it has been determined that the printer produces products having metric qualities consistent with the metric qualities of the input materials. The history of this contract would serve to indicate that a significant increase in accuracy can be achieved only at great expense to the Government in both time and money. For these reasons, it is considered to be in the best interests of the Government that the printer be accepted.

It is therefore requested that the necessary action be taken to close out the contract.

Sincerely yours,

[redacted]

Special Projects Branch
Advanced Mapping Division

1971 - Topacon
Telephone Co.!

25X1 [redacted]

File 99711-3

DEPARTMENT OF THE ARMY
THE ENGINEER GEODESY, INTELLIGENCE AND MAPPING
RESEARCH AND DEVELOPMENT AGENCY
FORT BELVOIR, VIRGINIA 22060

IN REPLY REFER TO:
ENGGM-TP

8 November 1966

Dear John,

In response to [redacted] letter, dated 11 October 1966, it is suggested that the Contracting Officer's reply letter contain the following:

"Reference is made to:

1. [redacted] letter, dated 11 October 1966, subject: "Proposal for a Test Program."

2. Telephone conversation between [redacted] on 1 November 1966.

3. Conference on 3 November 1966 at the Army Map Service between [redacted] and Government personnel.

Based on an evaluation of the proposal, item 1 above, the Government does not deem it advisable to modify the contract to include additional testing by [redacted] and that sufficient testing has been performed to justify action for correcting deficiencies in the [illegible] areas of concern. These areas are [illegible] [illegible], adjustment of [illegible] [illegible] detecting system.

In reference 2 above, [redacted] [illegible] decision relative to the proposal [illegible] that the Government is [illegible] performing additional testing of the exposure control system and [illegible] resume the final acceptance testing upon return of the preview and punch station assembly.

It was agreed at the conference on 3 November, reference 3 above, that:

ENGGM-TP

8 November 1966

1. [redacted] will submit a proposal to modify the existing timer associated with the frame edge detecting system, such that it will operate as a function of film displacement.

2. The subcontractor will modify the preview and punch station assembly to at least include structural rigidity for the film hold-down, alignment of the punches with the macroscope, and to position the punch die in a nominal plane with the film.

3. If the proposal for the timer is approved, then corrections to the raw stock metering and exposure patterns will be performed at the Contractor's plant at the time of modifying the timer design; if the proposal is not approved, then the two problem areas will be corrected immediately at the Army Map Service by Contractor personnel.

In the interest of correcting the deficiencies in a timely manner, it is requested that your submission of the proposal be expedited. It is also requested that the preliminary acceptance report on the printer be forwarded as soon as possible."

Sincerely yours,

[redacted]

Special Projects Branch
Technical Plans & Systems
Analysis Division

 file 99711-3

MEMORANDUM RECEIPT

5 October 1966
DATE

X1 TO: [redacted] GIMRADA

FROM: Responsible Officer for P&DS via [redacted] 25X

SUBJECT: Retention of Material

I hereby acknowledge receipt of the following:

Two (2) sets of engineering drawings - Unclassified

X1 Four (4) large manuals [redacted] - Unclassified

These items are Government property to be retained by another Government Agency (GIMRADA)

[redacted] 25X

Please return 1 signed copy(ies) of this receipt

SIGNATURE OF RECIPIENT

X1 To [redacted]

6 Oct 66

DATE RECEIVED

FORM NO. 752 REPLACES FORM 36-66
1 AUG 55 WHICH MAY BE USED.

(33)

CUSTODY RECEIPT - PROPERTY PASS
SEE INSTRUCTIONS ON REVERSE SIDE

DATE: 5 October 1966

PROPERTY ACCOUNT NUMBER:

ITEM DESCRIPTION *(Include identifying characteristics such as make, model, serial no.)*

Two (2) sets of engineering drawings - Unclassified
X1 Four (4) large manuals [redacted] Unclassified

These items are Government property to be retained by another Government Agency (GIMRADA)

ACKNOWLEDGEMENT OF RESPONSIBILITY

I acknowledge full responsibility for the protection and preservation of the above property while it is in my custody and am aware that I can be held pecuniarily liable for any loss or damage which might be determined to be caused by my negligence.

TYPED OR PRINTED NAME OF USER: X1 [redacted]

USER'S BADGE NO.: N/A

SIGNATURE OF USER: [redacted] 25X1

X1 SIGNATURE OF RE[redacted]

USER

Approved For Release 2005/06/23 : CIA-RDP78B04770A001600020002-2

FORM 10-61 1851 (29-33)